

Camera on Model Train

view the track from the proper perspective

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Without doubt, one of the secret wishes of many train fans is to be able to step into the role of the engine driver on a real train. With this project, you can at any desired moment consider yourself to be the master of your own model train, and you can direct it over the model train layout from the perspective of the engine driver.



In order to display the view from the model train on a television set or monitor, you will need a video camera, a transmitter and a receiver. Since these components are readily available at reasonable prices, they are not particularly interesting as DIY projects.

However, one thing that you will have to devote some attention to is the power supply for the entire setup. In order to ensure reliable transmission of the picture, the delivery of power to the camera and transmitter must be ensured at all times. Temporary loss of contact with the supply rail must not cause picture information to be lost. A mini-UPS (uninterruptible power supply) ensures that this does not occur.

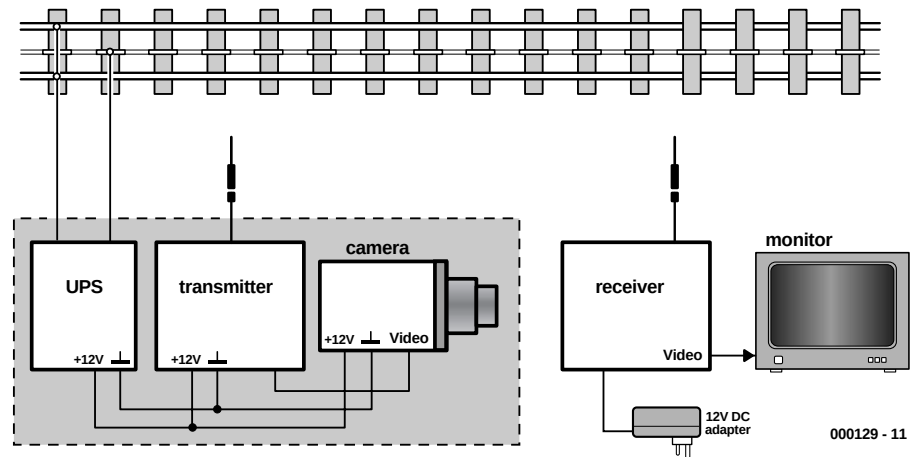


Figure 1. The complete installation consists of a camera, a transmitter, a UPS, a receiver and a monitor.

be used, and a brown ceiling joist in the model-train attic can more easily be interpreted as a green hill on the horizon.

All modern miniature cameras have automatic diaphragm controls, and the capabilities of these small technical marvels are extraordinary.

A typical camera has three leads:

- ground
- supply voltage
- composite-video output

Many cameras require a supply voltage of 12 V, but the latest generation needs only 5 V. With the 12-V types, the current consumption is around 80 mA, while the more recent 5-V types are happy with 20 mA or less.

Transmitter

The only type of transmitter that you should consider is an (approved) model that emits a signal in one of the allowed 2.4-GHz channels. If such a transmitter is used, noise-free picture transmission is possible over a range of several tens of meters.

For H0-gauge trains, the H0 OEM transmitter (available from Conrad Electronic) is very suitable. This transmitter, with dimensions of 62 × 22 × 18 mm, can be built into an H0 carriage without too many difficulties.

Receiver

Although there is a matching receiver for the H0 OEM transmitter, we decided to use the Marmitek Gigavideo 30 instead, since it is available as part of a set at a lower price than a separate H0 receiver. In addition, the Marmitek receiver comes in a nicely finished case.

The Marmitek 30 receiver has a composite-video output, so it can be connected to practically any television set. Several different adapter cables are provided with the receiver.

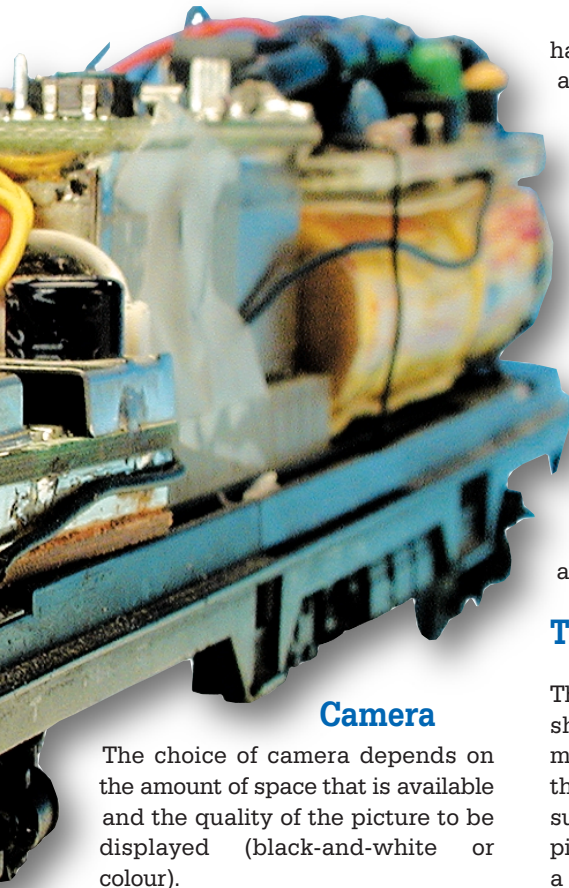
If your television set only has an HF aerial input, then you can use the version of the receiver that has a modulated HF output. The video signal can be found on UHF channel 36.

The channel frequencies of the H0 OEM transmitter differ somewhat from those of the Marmitek receiver, but good reception is possible on channels 1, 3 and 4 of the Marmitek unit. The following table summarises the usable settings when the Marmitek receiver is used with the H0 OEM transmitter:

Marmitek receiver	H0 OEM transmitter
Ch. 1: 2.411 GHz	Ch. 1: 2.4145 GHz
Ch. 3: 2.453 GHz	Ch. 4: 2.4565 GHz
Ch. 4: 2.473 GHz	Ch. 5: 2.4705 GHz

Important Notice

The use of the 2.4-GHz video transmitter module mentioned in this article is subject to type approval and radio regulations and may not be allowed in all countries in which *Elektor Electronics* is published.



Camera

The choice of camera depends on the amount of space that is available and the quality of the picture to be displayed (black-and-white or colour).

A colour camera has the advantage that the model landscape is presented more realistically, and a red signal lamp is readily visible. However, a black-and-white camera also has certain advantages. For instance, it allows IR headlamps to

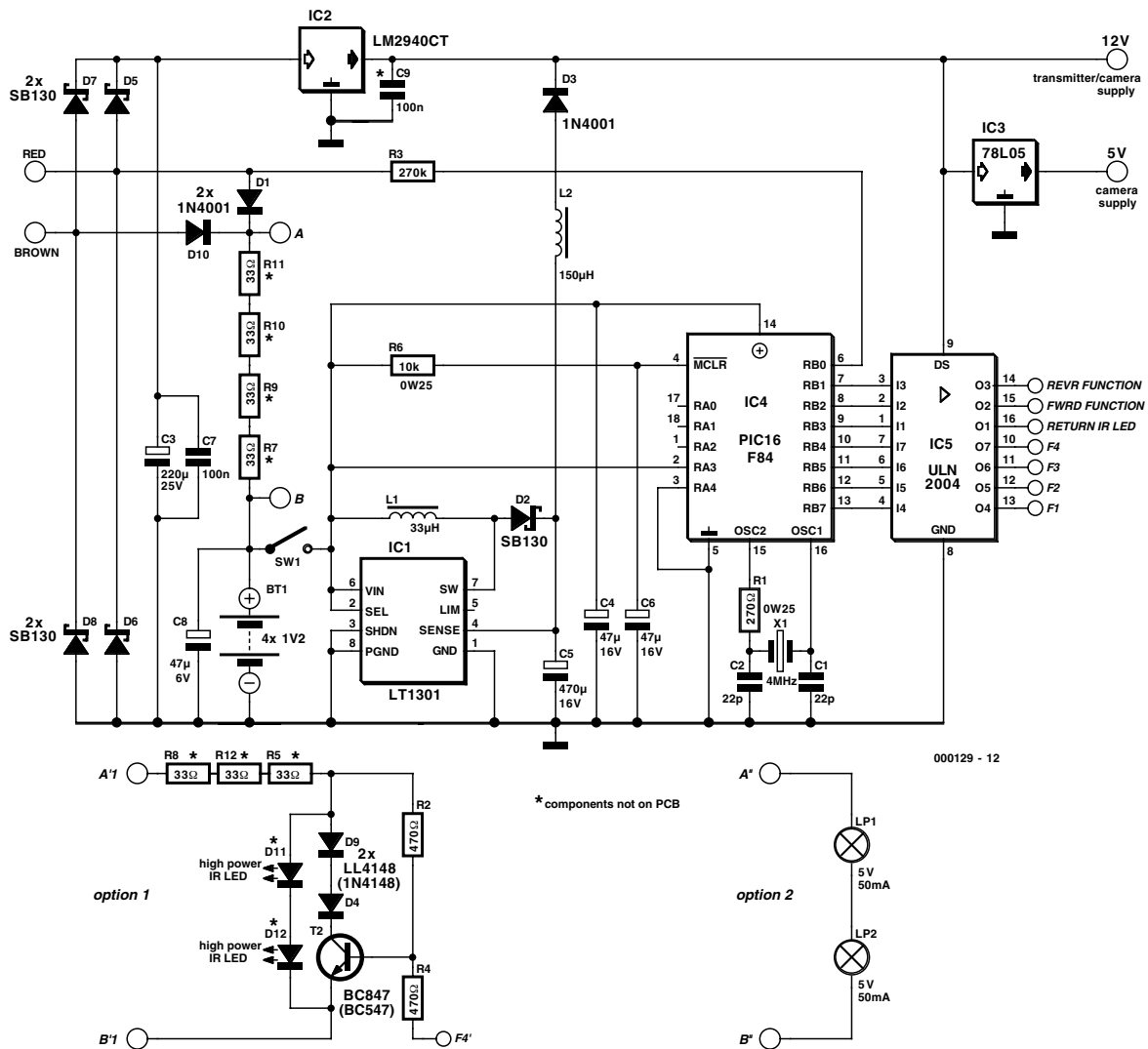


Figure 2. Schematic diagram of the UPS with the super locomotive decoder.

Although the components just described are some of the smallest commercially available modules, you can't just pop a camera together with its transmitter right behind the cab window of an H0 locomotive. A large part of the available space in the locomotive is taken up by the motor, so it is practically impossible to fit in the camera and transmitter. In some cases, it will be possible to fit only the camera in the locomotive, with the transmitter and associated electronics located in the carriage just behind the locomotive.

Another option is to build the camera and transmitter into a driving trailer carriage. A carriage that is especially suitable for this is the first version of the German 'Silberlingen' driving trailer. It is very well suited for housing a camera and transmitter module, since the camera can nicely look through the small window in the aisle door, and the carriage body has sufficient room for building in the camera, trans-

mitter and power supply.

Model railroad fans that only allow running stock on their tracks that has also run on a real railway in a particular configuration need not have compunctions about using this driving trailer, since it was actually used in combination with a BR212 or BR216 diesel, together with several second-class cars, in traffic running in the Dutch/German border region.

Electronics

Since so many ready-made modules are used, the amount of DIY electronics is very limited.

You could even consider omitting the fairly extensive backup power supply and powering the camera and transmitter directly from the rail voltage, via the 12-V regulator. However,

since the contact with the rail is quite frequently interrupted, the video picture will have a lot of interference. Consequently, there is a provision to compensate for these voltage dropouts.

It is also possible to keep the mechanical modifications to the carriage to a minimum by using only the NiCd cells as the power source. Of course, if the battery is not charged via the rail voltage, it is necessary to add connections to the carriage so that the cells can be charged. In this case, the red and brown leads must be brought to the outside, and the battery can be charged using a 12-V AC or DC mains adapter (such as that for the Marmitek transmitter or receiver). If power is supplied only by the NiCd cells, then the PIC, the ULN, C1, C2,

X1, R1, C6, C4, R6, D5, D7 and IC2 may be omitted.

On digital model railways, the rail voltage can serve as the primary power source. It is connected to the red and brown leads, and then rectified by D5–D8. Schottky types are used for these diodes, in order to keep the voltage drop across them to a minimum. Especially on track sections where EEDTs Pro signalling modules are used, the available voltage can drop to around 15 V.

Following the rectifier, a 220- μ F capacitor and a ceramic capacitor fil-

ter the supply voltage. The camera module in particular is very sensitive to disturbances on the supply voltage.

The fact that low supply voltages can be present on the track is also the main reason for using a low-drop voltage regulator to stabilise the supply voltage. With this solution, the supply voltage can be drawn from the rails in almost all situations. If you do not intend to use to use NiCd cells in the power supply, you can use these parts alone to provide power to the camera and transmit-

ter. In this case, however, it is recommended to make C3 as large as possible (for example, 4700 μ F/25 V).

On the other side of D1 and D10, we find the rectified rail voltage for charging the NiCd cells. Do not try to omit these diodes by drawing power directly from C3. Due to the protection diode between the input and output of the 12-V regulator, this would allow a charging current to flow from the backup source to the NiCd cells when the backup source is active.

Battery

Penlight (AA) cells are a good choice for the four NiCd cells. If the camera and transmitter depend entirely on this battery for their operating power, 700-mAh cells should be used. With this capacity, the camera and transmitter together can be provided with power for approximately 1.5 hours.

If you choose to draw primary power from the rail voltage, smaller-capacity cells may be used. In this case, you could also use the smaller AAA cells.

Do not use NiMH cells, since they cannot supply the high currents demanded by the step-up regulator.

A charging current of 70 mA has been chosen. This can be realised using a series resistance of around 130 Ω (R7 and R9–11). Since the power dissipation is approximately 1 W, the heat dissipation is shared by four 0.25-W resistors. Cut the leads of the resistors to 5 mm and solder them to each other. Then solder two flexible leads to the ends of the assembly, and insulate it with a length of heat-shrink tubing. The heat dissipation is now spread over the resistor chain, and the string of resistors can be placed nicely between the two rows of NiCd cells.

Part of the charging current can also be used for the IR headlight. The two high-power LEDs can be placed at the front of the driving trailer carriage at the level of the coupling, which thereby can be removed (see Option 1 in the schematic diagram).

If F4 of the locomotive decoder is not active, then R2 will drive T2 into conduction, and the charging current for the battery will flow through T2, D4 and D9. The voltage drop across the two diodes and the transistor lies below the threshold voltage of the IR LEDs (1.1 V), so they do not emit any IR light.

By contrast, if the F4 output of the ULN2004 is active, transistor T2 is blocked. The charging current then flows through the IR LEDs, and these illuminate the track.

The components in Option 1, with the exception of the IR LEDs, can be mounted on printed circuit board C (SMD), but the circuit can also be build using conventional compo-

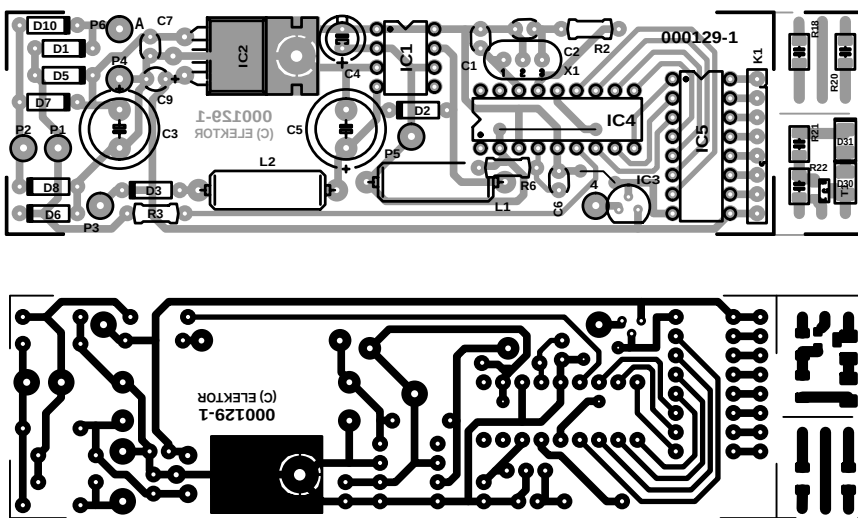


Figure 3. The associated printed circuit board matches the width of the carriage (board available from Readers Services).

COMPONENTS LIST

Resistors:

R1 = 270 Ω
R2, R4 = 470 Ω (option 1)
R3 = 270k Ω
R5, R8, R12 = 33 Ω (option 1)
R7, R9, R10, R11 = 33 Ω
R6 = 10k Ω

Capacitors:

C1, C2 = 22pF ceramic
C3 = 220 μ F 25 V radial
C4 = 47 μ F 25V radial
C5 = 470 μ F 16V radial
C6 = 47 μ F 16V radial
C7, C9 = 100nF
C8 = 47 μ F 6V radial

Inductors:

L1 = 33 μ H (40 turns, 0.25 mm diam./SWG32 enamelled copper wire on ferrite rod, 4 mm dia., 15 mm long)
L2 = 150 μ H miniature choke

Semiconductors:

D1, D3, D10 = 1N4001
D2, D5–D8 = SB130
D4, D9 = 1N4148 (option 1)
D11, D12 = high-power IR-LED (option 1)
T1 = not fitted
T2 = BC847 or BC547 (option 1)
IC1 = LT1301CN8 (Linear Technology)
IC2 = LM2940CT
IC3 = 78L05 (only with 5V camera)
IC4 = PIC16F84 (programmed, for Super-LoCo Decoder, # 996523-1, see Readers Services, items October 1999)
IC5 = ULN2004

Miscellaneous:

X1 = 4 MHz quartz crystal
L1, L2 = miniature bulb 5V/50mA (option 2)
PCB, order code 000129-1

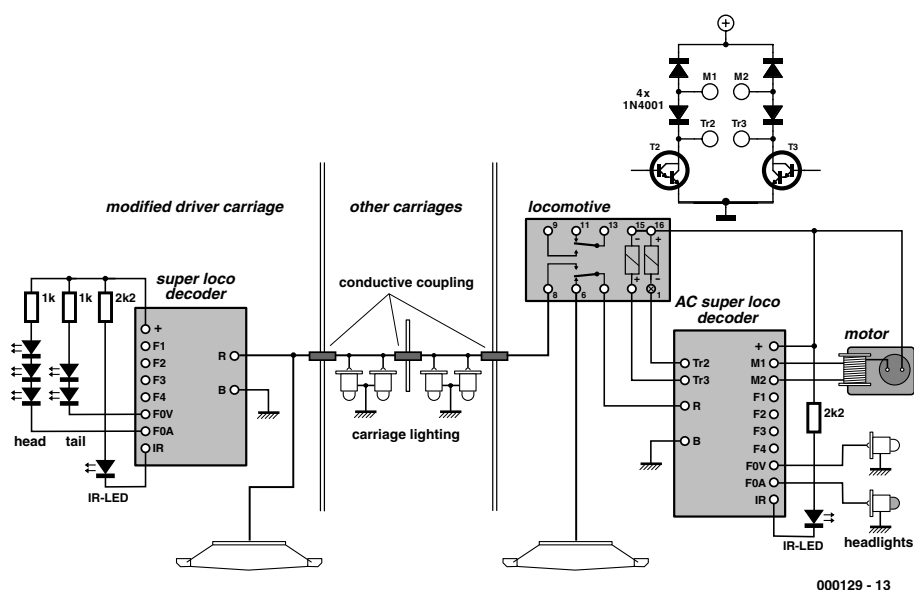


Figure 4. Sample connections for a Märklin system.

nents (using the part numbers in parentheses).

Option 2 yields a design with two small incandescent lamps, which can be used for interior illumination.

Step-up regulator

The step-up regulator is completely integrated into the LT1301CN8. This IC manages to convert the 4.8-V voltage from the NiCd battery into 12 V at a maximum current of 200 mA.

Inductor L1 is an important part of the

step-up regulator. Although it is very tempting to use a ready-made, colour-coded inductor here, such components cannot handle the high current level (around 0.5 A). Winding the coil yourself, however, is not especially difficult. Forty turns of 0.25-mm diameter enamelled copper wire on a ferrite rod (4 mm thick and 15 mm long) will make a satisfactory inductor.

The rectified voltage is found across C5, and it is fed back to the

sense input of the regulator. This allows the voltage to be held very closely to 12 V.

L2 is added to the circuit to filter out the last remnants of HF ripple in the supply voltage. In this case, a ready-made component may be used.

D3 forms the switch between the supply voltage from the rails and the backup supply. If the voltage at the output of the 12-V regulator drops below 11.3 V, the step-up regulator will take over the supply to the camera and transmitter, without any visible effect on the video image.

Locomotive decoder

The right-hand part of the schematic diagram consists of a stripped-down super locomotive decoder (996523-1).

The motor control logic is entirely omitted, the low-voltage detection circuit is simplified and hardware address selection using diodes is omitted. However, all functions and the IR address-transmission output are still available via the ULN2004.

The three yellow LEDs for the front running lights are connected to the REVR (reverse) output via a 1-k Ω resistor, and the two red LEDs of the rear signal lamps are connected to the FWRD output. The (SMD) resistors can be mounted on circuit board B.

The return IR LED output can drive a LED mounted underneath the carriage body, so that the address can be detected when the train is being pulled and pushed.

Using the EEDTs-Pro software, the address of the locomotive decoder is set to the same value as address of decoder in the locomotive at the other end of the train.

Modifications

Mounting the components on the printed circuit board should not present very many problems. However, C8 and C3 should be mounted horizontally instead of vertically, in order to save height. Some space can also be saved by soldering the ICs directly to the circuit board, instead of using sockets.

If the driving trailer carriage with the camera is used on a model railway with stop sections for the sig-

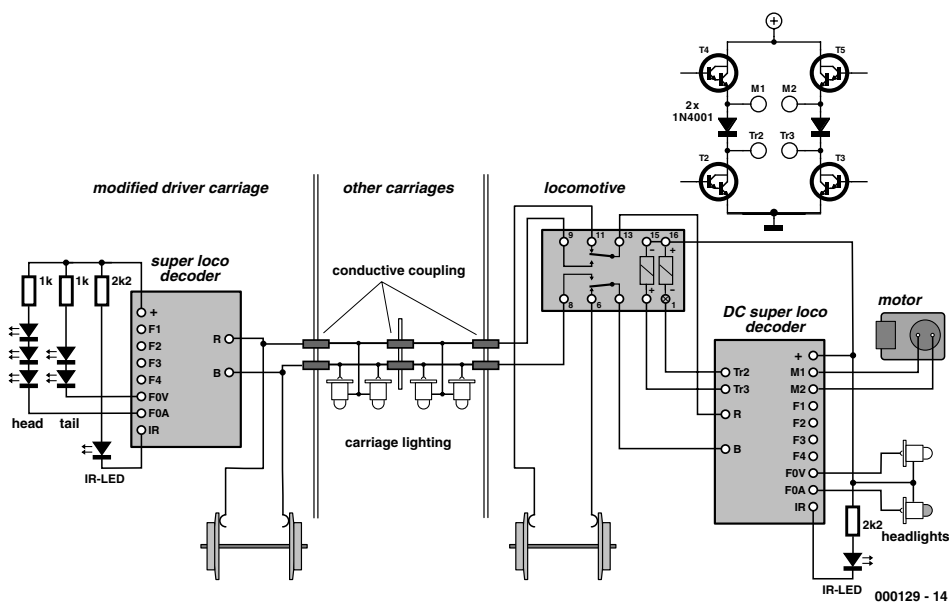


Figure 5. Sample connections for a two-rail system.

nals, then a sliding contact must be mounted under the carriage to prevent the entire train from coming to a halt after passing the signal. In addition, the decoder in the locomotive must receive its power from whichever slider is at the front of the train.

The locomotive should preferably be fitted with a super locomotive decoder, which can decode the new Motorola format, so that both the decoder in the driving trailer carriage and the locomotive decoder know which direction the train is travelling. This ensures that the front and rear signal lamps will always be illuminated correctly.

Another advantage of the super locomotive decoder is that it can easily drive the switchover relay for the slider. In order to ensure reliable operation of the bistable relay when the super locomotive decoder is controlling a Märklin-series motor, two diodes have been included in the motor control stage (see **Figure 4**). If necessary, these diodes can be soldered on the printed circuit board in place of D10 and D11 (but with the opposite polarity!), with D10 and D11 replacing the wire bridges.

In addition to these modifications, C4 on the locomotive decoder circuit board must be changed to 220 $\mu\text{F}/25\text{ V}$.

Figure 5 shows the situation for a two-rail track.

Replace the SMD electrolytic capacitor C4 on the super locomotive decoder in the locomotive with a normal electrolytic capacitor with a value of 220 $\mu\text{F}/25\text{ V}$. Since there are already diodes on the circuit board in the DC version, no additional measures are necessary to allow the bipolar relay to be connected. The relay coils are connected to the collectors of T2 and T3, which are the connection points for the field coils in the AC version.

Cutting and breaking

When we looked for a carriage that was suitable for housing the camera, transmitter and power supply, our choice fell on a Fleischmann model. However, Roco also has a suitable type in its assortment.

Don't use a metal carriage, such as the Märklin models, since there is a

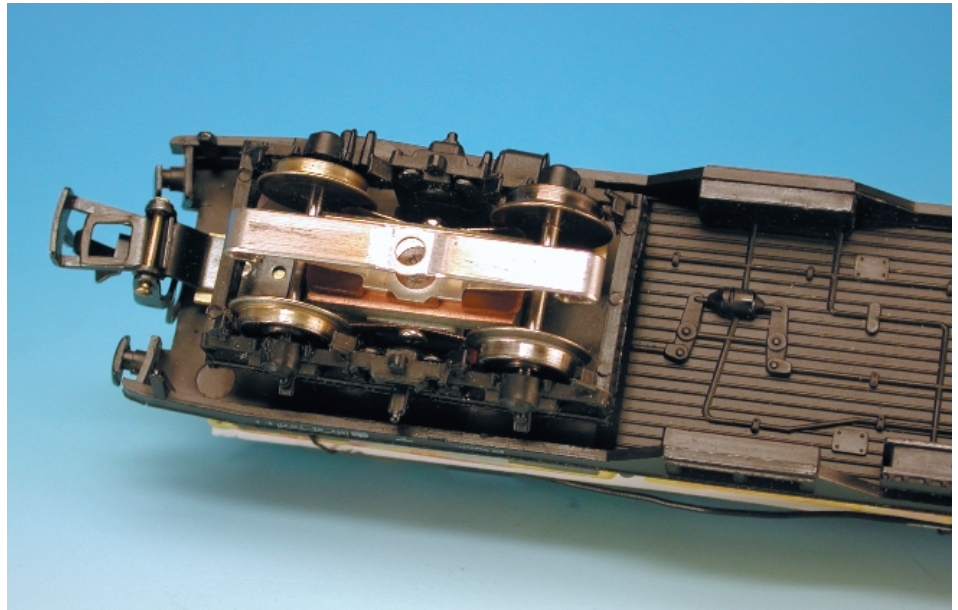


Figure 6. The slider under the driving trailer carriage.

good chance of a short circuit, and the transmitter will also be inside a Faraday cage.

The first thing to do is to remove the interior elements of the carriage. After this, turn your attention to the lamp holders and the diodes for switching over the front and rear lamps.

The lamp holders for the interior lighting must also be broken off. Grasp each one with flat-jawed pliers and rock the pliers back and

forth until the lamp holder breaks off.

There is no longer any reason to illuminate the interior of the carriage, so you can dispense with interior lighting.

In general, the pivots for the bogies will present problems, since they protrude around half a centimetre above the floor of the carriage. Make new pivots, using (for example) flat-head M2 screws and a few washers. Make sure that the bogies turn smoothly, and that the pivots protrude above the floor of the carriage as little as possible.

If the carriage is used on a Märklin system,

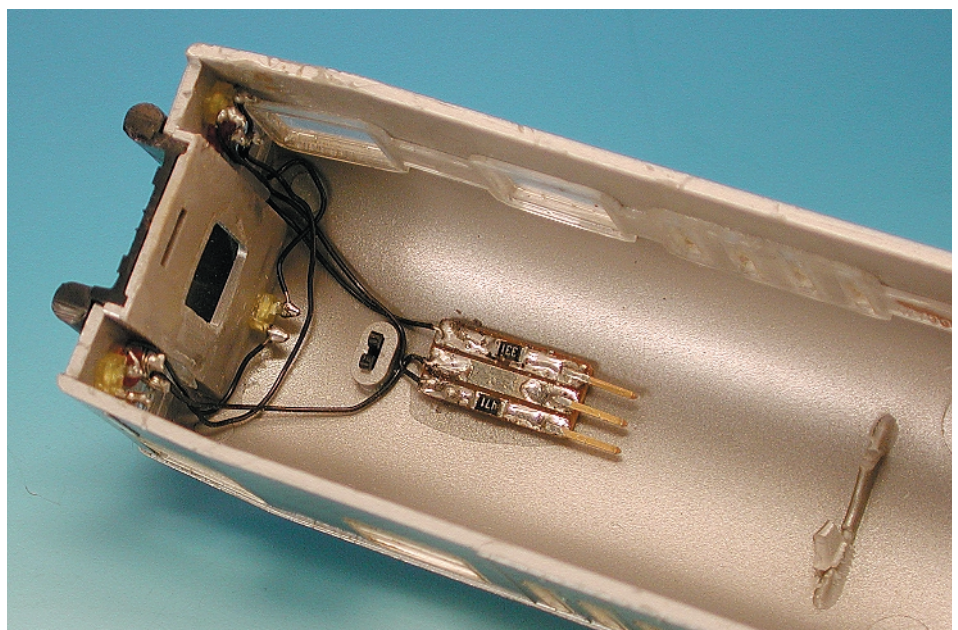


Figure 7. Connecting the front and rear signal lamps.

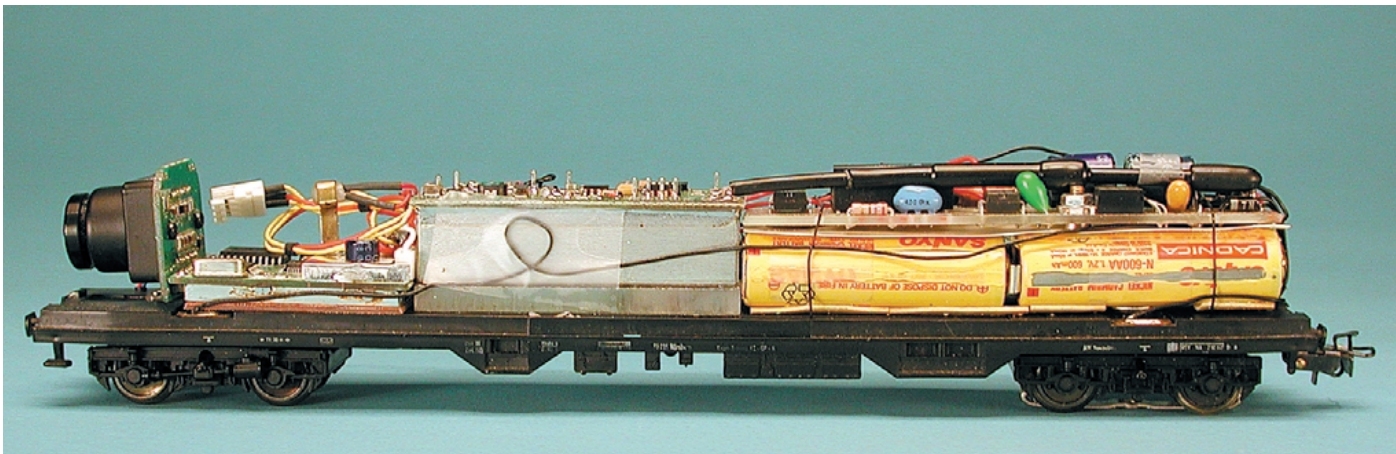


Figure 8. Placement of the components in the driving trailer carriage.

it is better to replace the insulated wheels with uninsulated types, since this makes for better contact with the rails, and contact rails will react properly when the carriage passes over them.

The Fleischmann carriage does not have a NEM standard shank, so the Fleischmann coupling cannot be directly replaced by a Märklin coupling. However, if you use a small strip of 0.5-mm thick brass to extend the Märklin coupling, it is possible to attach the carriage to a Märklin train.

If the camera driving trailer is used on a Märklin system with stop sections for the signals, a sliding contact must be mounted under the driving trailer carriage to prevent the entire train from coming to a halt after

passing the signal. A connection must be made through the length of the train between this contact and the switchover relay in the locomotive. This can be done using conductive couplings, Roco multiple-lead connective couplings or a thin piece of wire running through the train.

If you use a piece of wire for the connection, it is practical to use pin-and-socket connectors at the couplings, so the cars can be stored individually. The turned pin sockets of a good-quality IC socket are a very good choice for such connectors, due to their compact dimensions. Solder on the wires as shown in the draw-

ing, and slide a short piece of heat-shrink tubing over the pin, to provide insulation and prevent the wire from breaking off so quickly.

The supply current must switch between the slider under the locomotive and the slider under the driving trailer, depending on the direction that the train is travelling. A small, bipolar 12-V relay located in the locomotive is used for this (Takamisawa RALD12W-K).

If the rail voltage is used to supply power to the camera and transmitter on a Märklin railway, a slider must also be mounted under the bogie. The best choice here is a

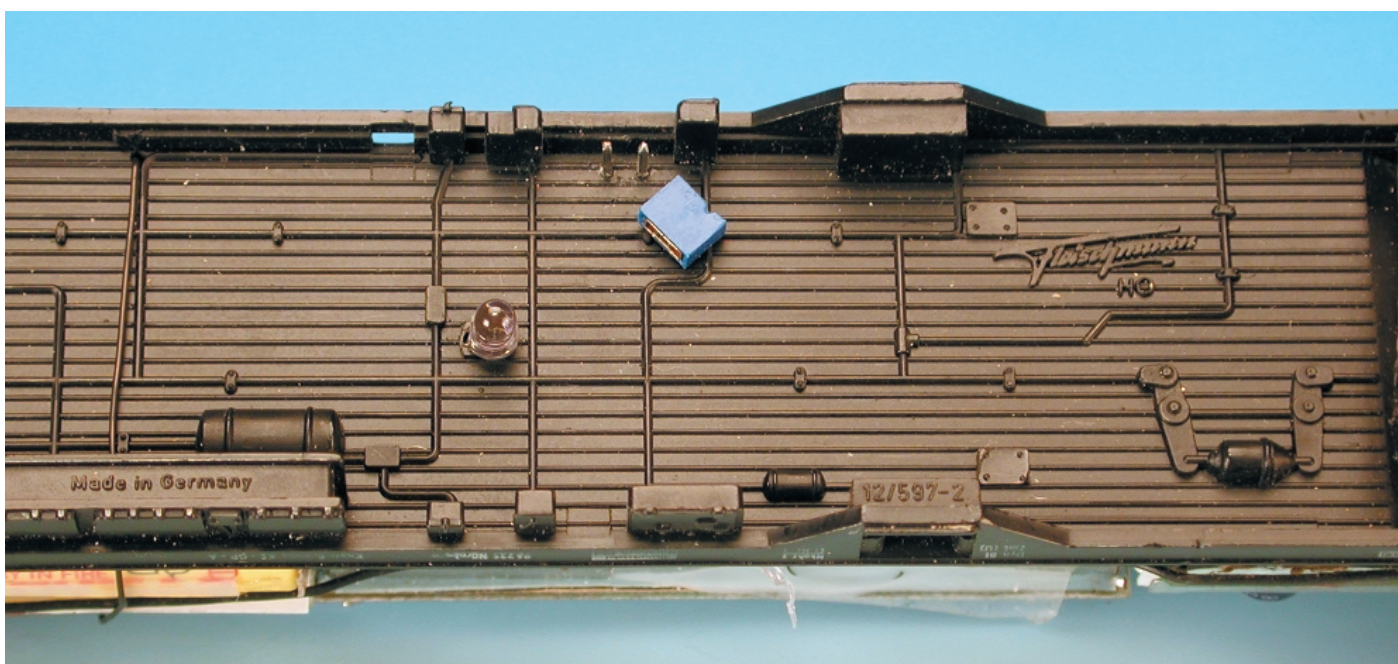


Figure 9. The IR LED and jumper switch in the middle of the carriage body.

Märklin type 7198 sliding contact, which should be placed under the trailing bogie. This reduces the chance of derailment.

In order to make the video picture as clear as possible, it is a good idea to remove the small plastic window in front of the camera lens. This can be easily done using a small multi-purpose drilling tool and a routing bit.

Refitting the carriage with head and taillights is a finicky little job. A true model builder will not have any

ing crazy glue.

In order to avoid problems with the carriage body during disassembly, it is best to use a pin-and-socket connector on circuit board B for the supply leads of the LEDs. A three-pole SIL header can be used as the connector. It is also possible to butcher the previously mentioned IC socket with turned sockets to produce a socket strip with three contacts. Insert three pieces of wire (left over from mounting wire-wound resistors) into the connector and cut

important to mount the camera firmly.

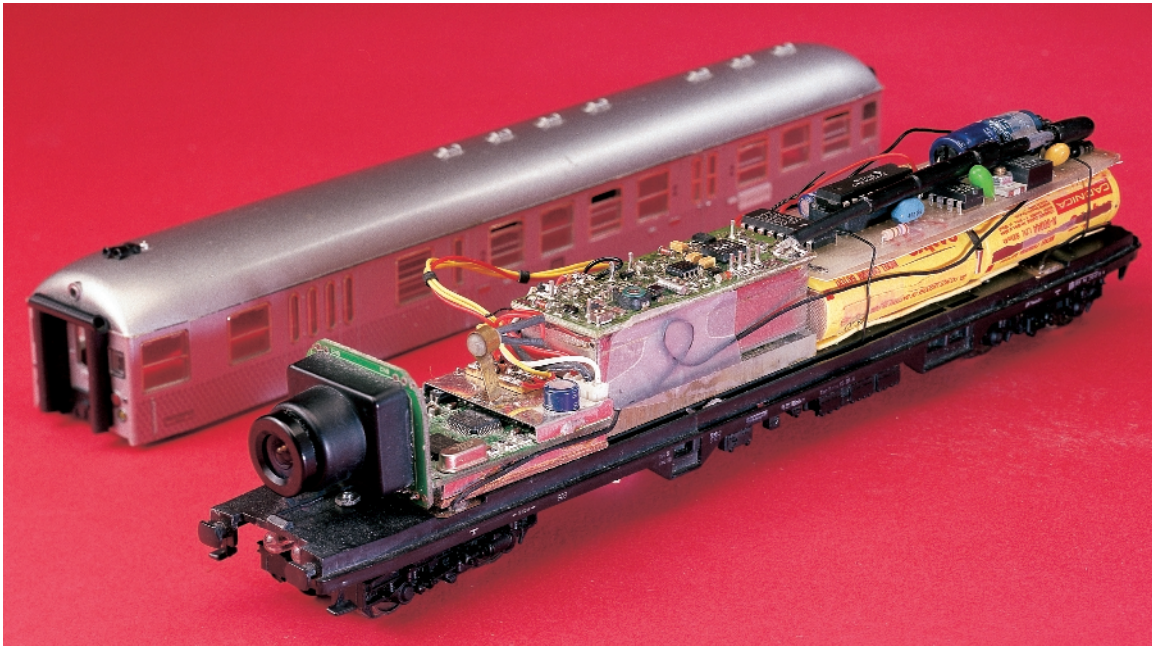
The transmitter is placed in the middle of the undercarriage. In order to position the aerial nicely above the NiCd cells and the printed circuit board, lay it on a piece of 4-mm thick Plexiglas and secure it with contact cement.

If optical address recognition is used, a notch for the connecting leads of the IR LED must be made in the Plexiglas, since the transmitter is located just above the IR LED. Incidentally, this LED can be mounted very simply by drilling two 1-mm holes 0.1 inch (2.5 mm) apart in the undercarriage, and

inserting the LED from the bottom.

In order to prevent the NiCd cells from being completely discharged, it must be possible to disconnect them when the carriage is not on the track. A jumper 'switch', such as commonly used in PCs, can be used for this purpose.

Here again, drill two small holes 2.5 mm apart. Pass two small pins through these holes from the top side of the undercarriage and secure them with



serious problems with this, but if you don't fall in this category, you can do without it.

The Siemens type TLUY 2400 and TLUY2401 yellow LEDs are very suitable for the headlights, while red 3-mm LEDs can be used for the tail lights. For an attractive result, file the 3-mm LEDs flat.

The three yellow LEDs are fastened with a bit of crazy glue. Apply a very small amount of glue to the inside surface of the carriage body around the lamp opening, and then press the LED into the opening. The collar of the LED will then embed itself in the glue.

The red LEDs for the taillights are attached by first applying glue to the LED and then pushing the LED into the lamp opening. The openings for the lights are actually a bit too large, so it is a good idea to use a void-fill-

off the free ends 4 mm from the connector.

Leave the wires in the connector, and solder them longitudinally onto the printed circuit board. Mount the two current-limiting resistors on the circuit board, and file the portion of the board without components into an arc that matches the roof of the carriage. Fasten the circuit board under the roof of the carriage using crazy glue, after first checking that the connector can be slid on.

The connections between the LEDs and the small printed circuit board are made using thin pieces of wire (wire-wrap wire), as shown in **Figure 4** or **Figure 5**.

Now it's time to mount the camera. A right-angle type is mounted on the undercarriage, while a surface-mount type gets a place in the carriage body. In any case, it is

a drop of glue. This 'switch' can now be closed with a jumper.

The final step is to mount the NiCd cells along with the power-supply circuit board. The four cells are connected in series by soldering small wires to their terminals. Avoid heating the cells for too long. You can also use cells with solder tabs, but these are generally much more expensive.

The power-supply circuit board and the NiCd cells can be secured to the undercarriage using silicone glue. However, before doing this, you must first verify the proper operation of the circuit board and check that it fits into the carriage body.

Hopefully, these extensive instructions will provide an adequate basis for finding solutions in many individual situations.

Nearly all of the components used are stock items from Conrad Electronic (<http://www.conrad-electronic.com>), so availability should not be a problem.

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